EXPLORE

Newsletter for the Association of Exploration Geochemists

NUMBER 82 JANUARY 1994

TECHNICAL NOTES

Progress with the geochemical map of Ontario pilot project

Introduction

Ten years ago, when a Geochemical Map of Ontario (GMO) was first considered (Fortescue 1983), the project was considered impractical scientifically and logistically. Since then, advances in geochemical mapping worldwide have demonstrated that mapping of areas the size of Ontario (circa. 750000 km^2) are now relatively common (Darnley and Garrett, 1990; Dickson and Hsu 1993). As the result of information obtained by the senior writer during a trip to Europe in 1990 (Fortescue 1990), the technical feasibility of a GMO was reconsidered. The new goal was to develop and test a "low density" geochemical mapping approach appropriate to the diverse landscapes of Ontario and based on the minimum of logistical support. This would test whether on not one could delineate province-wide geochemical patterns pertinent to: 1) mineral exploration; 2) environmental geochemistry; and 3) the health and nutrition of plants, animals and man. Such an approach might be considered as the "low density" component of a system of successive approximations linking a province wide map to regional and local landscape geochemical mapping.

Recent research in geochemical mapping

Advances in geochemical mapping pertinent to the GMO have been described recently from: (1) Scandinavia and Europe by Bolviken et al., (1990 and 1992); (2) China by Xie (1990) and Xie and Yin (1993); and (3) the ICGP Project 259 (International Geochemical Mapping) by Darnley and Garrett (1990) and Darnley (1992 and 1993). Successful "low density" geochemical mapping of large areas of glaciated terrain has also been reported. For example, Ottesen et al. (1989) described a successful map based on 684 "overbank samples" collected from an area of 324,220 km^2 in Norway (average sample density 1/500 km^2); and Koljonen et al. (1989) described another successful map based on 1050 "composite till samples" collected from an area of 337,030 km^2 in Finland (average sample density 1/300 km^2).

Xie and Yin (1993), reported on experience gained from mapping an area of 4 million km^2 in China (average sample density of 1/km^2). These writers provide a general conceptual model as a guide to the interpretation of province patterns on geochemical maps (Fig. 1). The model has a three-level, nested, structure which links geochemical patterns of various kinds obtained at different map scales. Using the terminology defined by Xie and Yin (1993), the model illustrates relationships among: (1) local geochemical anomalies, (2) regional geochemical anomalies, and (3) provincial anomalies. These writers also provide "geochemical threshold" values for 14 elements (Ag, As, Au, Be, Bi, Cd, Cu, Hg, Mo, Nb, Pb, Sb, Sn and W) used to delineate Chinese geochemical province patterns (Table 1). These data indicate the high standard of chemical analysis required for modern geochemical mapping in China and elsewhere.

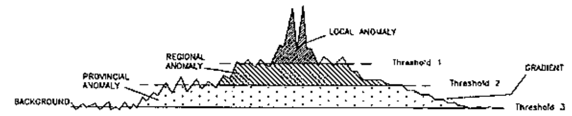

Figure 1. Profile showing the three-level nested structure of local, regional, provincial and gradient geochemical patterns. (Modified after Xie and Yin, 1993.)

Table 1: Threshold values of regional anomalies. (From Xie and Yin, 1993)

Elements	Thresholds	Elements	Thresholds
Ag	80-120 ppb	Hg	15-80 ppb
As	12-25 ppm	Mo	1.5-2.5 ppm
Au	1.0-2.0 ppb	Nb	10-20 ppm
Be	2.5-3.0 ppm	Pb	15-40 ppm
Bi	0.2-1.0 ppm	Sb	1.0-2.0 ppm
Cd	0.2-0.5 ppm	Sn	2.5-4.0 ppm
Cu	30-50 ppm	W	1.2-4.0 ppm

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CONTENTS

Information for Contributors to EXPLORE

Scope This Newsletter endeavors to become a forum for recent advances in exploration geochemistry and a key informational source. In addition to contributions on exploration geochemistry, we encourage material on multidisciplinary applications, environmental geochemistry, and analytical technology. Of particular interest are extended abstracts on new concepts for guides to ore, model improvements, exploration tools, unconventional case histories, and descriptions of recently discovered or developed deposits.

Format Manuscripts should be double-spaced and include camera-ready illustrations where possible. Meeting reports may have photographs, for example. Text is preferred on paper and 5- or 3-inch IBM-compatible computer diskettes with ASCII (DOS) format that can go directly to typesetting. Please use the metric system in technical material.

Length Extended abstracts may be up to approximately 1000 words or two newsletter pages including figures and tables.

Quality Submittals are copy-edited as necessary without re-examination by authors, who are asked to assure smooth writing style and accuracy of statement by thorough peer review. Contributions may be edited for clarity or space.
All contributions should be submitted to:

EXPLORE
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Denver, CO 80225, USA

Information for Advertisers

EXPLORE is the newsletter of the Association of Exploration Geochemists (AEG). Distribution is quarterly to the membership consisting of 1200 geologists, geophysicists, and geochemists. Additionally, 100 copies are sent to geoscience libraries. Complimentary copies are mailed to selected addresses from the rosters of other geoscience organizations, and additional copies are distributed at key geoscience symposia. Approximately 20% of each issue is sent overseas.

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EXPLORE

Newsletter No. 82 JANUARY 1994

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NOTES FROM THE EDITOR

This issue of **EXPLORE** contains an eclectic mixture of news and information. The feature article, by John Fortescue and Richard Dyer, sets the stage for regional geochemical mapping in the province of Ontario. Lynda Bloom warns us about carry-over contamination during rock sample preparation and Gwendy Hall brings our attention to a Chinese-developed method for "cleaning-up" fire assay litharge.

Readers will note that the AEG is moving its business office to Nepean, Ontario, Canada (near Ottawa). Hopefully, this move will make dealing with the AEG much easier and convenient for our membership.

Contributor's deadlines for the next four issues of **EXPLORE** are as follows:

Issue	Publication date	Contributor's deadline
83	April 1994	February 28, 1994
84	July 1994	May 31, 1994
85	October 1994	August 31, 1994
86	January 1995	November 30, 1994

Owen Lavin
Editor **EXPLORE**

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AEG OFFICE MOVED

As of December 10th, 1993, the AEG office will be located near Ottawa in Nepean. Correspondence should be directed to:

AEG
P.O. Box 26099
72 Robertson Road
Nepean, Ontario, K2H 9R0
CANADA
TEL: (613) 828-0199
FAX: (613) 828-9288

The new Business Manager will be Mrs. Betty Arseneault. She will be taking on this role in a part-time capacity. The AEG Council regrets that the recent move to a full-time Business Manager in Vancouver did not prove successful and apologize to all members who have been inconvenienced by this. We realize that some members may not have been receiving either the Journal or **EXPLORE** or both, and will strive to rectify this situation as quickly as possible.

PRESIDENT'S MESSAGE

After several years in Vancouver, the Business Office is being moved to Ottawa, where it will be close to the next President, senior Vice President and Editor of the Journal of Geochemical Exploration. At a time when the return on investments is very low, the Executive could not justify the cost of a full-time Business Manager and lease of office space. The new arrangements are above.

On behalf of the Association, I extend our appreciation to Ben Ainsworth and David Jenkins whose office we partially occupied and to Stan Hoffman, Lorraine Kluber and more recently Art Clendenan for their efforts in managing the business of the Association.

Many members of the Association are involved in various aspects of environmental geochemistry. I have recently joined the CSIRO multi-disciplinary Minesite Rehabilitation Research Program (MRRP) which works with mining companies to restore mines, waste rock piles, tailings empondments, water quality and ecosystems. In the USA, a multi-agency task force has recently been established to address problems associated with Inactive and Abandoned Mine Lands (IAML). Similar opportunities for geochemists to assist in the rehabilitation of mine-sites exist in many other countries (eg. MEND in Canada).

However, the exploration geochemist has the opportunity to play a more pro-active role. The knowledge of the chemical and physical properties of mineralization, host rocks, groundwater and other sampling media gained during the exploration phase can be used in the design of new mines to prevent such products as acid mine drainage, poor water quality, dust and damaged ecosystems. Ultimately, the need for rehabilitation will diminish if we as geochemists accept this challenge.

Council has just approved the appointment of two new Regional Councillors: Peter Simpson for U.K. and Republic of Ireland, and Larry James for southeast Asia. Such appointments will serve to raise the profile of the Association in these three regions. I urge members to contact their Regional Councillors, and visiting members should regard Regional Councillors as a source of information and possible assistance.

Graham F. Taylor
President
CSIRO Exploration and Mining
P.O. Box 136, North Ryde
New South Wales, Australia

NOTES FROM THE SECRETARY

Once again it is time to bring you up to date on the activities of your Council and in this issue I will bring you up to date on Council's actions in 1993.

Actions of February 24, 1993

1. Council approved the applications of 6 Affiliate Members and 1 student member.
2. Council approved the purchase of "Omni Page Professional" software to assist in the of the bibliographic data base

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Notes from the Secretary

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3. Council approved a motion to cover the travel expenses of Art Clendenan Prospective Business Manager) to attend the AEG Annual General Meeting in Denver, Colorado on April 16, 1993
4. Council approved a motion to award Eion M. Cameron (JGE Editor) the Past Presidents Medal of The Association of Exploration Geochemists at the 1993 Annual General Meeting
5. Council approved a motion to provide (US)$2,000 seed money to the Organizing Committee of the 17th IGES. Money to be repaid from any profit from the meeting.

Actions of April 16, 1993

1. Council approved the applications of 2 Voting, 24 Affiliate, and 3 Student Members.
2. It was suggested to Council that several Regional Councillors be added to represent areas that have strong membership.
3. Council approved a motion to hold the 1993 Annual General Meeting in conjunction with the SME meeting in Albuquerque, New Mexico on February 14, 1993.
4. Council approved a motion to amend the By-laws to establish a fixed term of office for Council and the Executive
5. Council approved a job description for the position of Business Manager.

Actions of June 16, 1993

1. Council approved the application of one Fellow.
2. Council approved a motion to pay $(CAN)500 per month for office space in Vancouver, BC (this space had previously been donated).
3. Council approved a motion to hire Art Clendenan as Business Manager for the Association with a six month probationary period.

Actions of August 18, 1993

1. Council approved the applications of one Fellow, 10 Member, and two Student for membership in the Association.
2. Council approved By-law amendments for submission to the membership at the next election.
3. Council approved a motion to allow the Treasurer to move investment funds between banks to maximize returns.
4. It was reported that all existing AEG bibliographic data had been entered into the computer.

Actions of October 20, 1993

1. Council approved the list of candidates for the 1994 Council election.
2. Council passed motions to elect two new Regional Councillors; Larry James for southeast Asia and Peter Simpson for the United Kingdom and Republic of Ireland.
3. Gunter Matheis (Regional Councillor for Europe) proposed holding the 19th IGES in Germany in 1999, and has been asked to submit a detailed proposal.

Sherman P. Marsh
Secretary of The Association of Exploration Geochemists
U.S. Geological Survey
MS 973, Denver Federal Center
Denver, CO 80225, USA

LETTERS

Sir:

The tests of the CHIM method by the U.S. Geological Survey (**EXPLORE**, No. 79; also JGE, v. 46 No. 3 p.257-278, and Abstracts, 16th IGES, Beijing, 1993 p.171) provide a refreshing evaluation, based on electrochemistry and experimental methods rather than "standardized black box" results; however, the mineralization sites used in the tests deserve comment. Perhaps they did not permit testing the main claims of the inventors of the system.

The Russell Gulch (Kokomo mine) and the Cross Mine areas of the Colorado Mineral Belt are characterized by very narrow, discontinuously mineralized high grade gold-silver-base metal veins, extensively mined and explored prior to 1910 by pits and underground workings. At shallow depths at the mine sites described, it would be surprising to find significant quantities of any ore minerals remaining undisturbed. The main geochemical anomalies associated with these deposits are likely to be derive from pulverized mineralization along the edges of old pits along vein structures, which definitely yields pronounced "soil" anomalies. In their vicinity, over more than a century, contamination has spread from old ore piles, transport routes, small concentration plants (see Fig 1) whose locations bear no geologic relationship to mineralization. The present distribution of metals in soil or bedrock in these areas thus does not remotely approximate a concealed large or world-class ore deposit.

Figure 1 is a turn of the century scene at the Honerine Pb-Zn-Ag mine near Stockton, western Utah USA. It is an example of the kind of unmapped pollution sources that confound element distribution studies in such environments. The photo shows a small "portable" jig concentration plant (for salvaging lead concentrates from waste dumps), whose location depended mainly on water, access, and the owner. Similar plants are in use today in developing countries. Tailings distributed by such short-lived operations rapidly become unrecognizable, yet may give strong local anomalies.

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Letters

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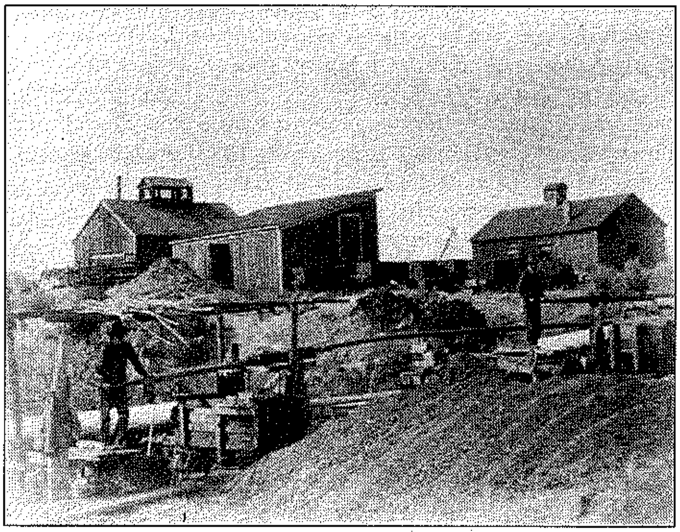

Figure 1. Hand-operated mineral jigs for separation of galena from reworked mine dump material at Honerine drain tunnel, Bauer Tooele County, 1912. Lester J. Neilson collection. Courtesy Utah State Historical Society.

The Colorado tests did not determine what the CHIM method might measure over a large disseminated or massive metal deposit, the usual target of today's explorationist; however, the interesting discussion of the electrochemical basis of the method, and its tendency to extract soil ions at electrode sites, certainly suggest that CHIM anomalies may be only surficial features. It will be interesting to follow ongoing research through subsequent publications.

Laurence P. James
BHP Minerals Exploration
Hong Kong

Reply to L.P. James, BHP Minerals

Mr. James' letter to **EXPLORE** No. 82 raises very valid concerns about the contamination problem at the Kokomo and Cross mine sites which were used extensively in our research on the CHIM method. We were well aware of such problems and, based on what historical evidence was available and careful site evaluation, selected our test traverses to minimize such effects; however, our principal objective was not to demonstrate that the CHIM method could detect large concealed deposits, but to test the CHIM equipment we had developed, and to understand the fundamental processes occurring during an actual electrogeochemical extraction. Because we were starting this research with no prior experience we needed to know if our equipment was adequate, whether our electrode designs were functioning properly or if there were problems with the electronic controls or charge metering equipment. In addition, the Russian literature didn't adequately address such questions as the collection efficiency of the process, the optimum current density and the sample volume, nor did it provide comparisons with more conventional total and partial soil extractions. Questions such as these, we believed, needed to be answered before we used the new method in the field to demonstrate its advantages in an exploration mode. Therefore, contamination was not a primary concern, but a site where we could conduct repeated studies over an extended time period was.

In 1990 and 1991 we conducted tests on the Carlin trend in Nevada, and at Johnson Camp, Arizona, where a Cu-Zn replacement deposit has been drilled but not developed. Severe funding limitations have prevented further work outside the Denver area for the past two years. Fortuitously, in tests conducted locally we focused on obtaining a better understanding of the CHIM process. This resulted in our rediscovery of a serious problem in the conventional CHIM methodology which we reported in **EXPLORE** No.79. We have reported results of our tests at Carlin and Johnson Camp by oral presentations, but, because these tests did not involve true electrogeochemical extractions, there are no plans to publish the results in the near future. The Carlin and Johnson Camp tests, nevertheless, did increase our understanding of the problems with earlier technology. As a result, we have made a complete redesign of the CHIM electrode for which a patent application is pending and which we hope to report in a coming issue of **EXPLORE**.

We now believe that we have developed the technology to conduct, for the first time, a true CHIM extraction using either or both cation and anion collection electrodes. Clearly, further testing of the new electrodes is needed and we are

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ready to test the method at locations such as suggested by Mr. James. Because insufficient internal funds limit testing to the Denver area, we are exploring the possibilities of joint industry-USGS test programs through Cooperative Research and Development Agreements (CRADA's). We welcome anyone in industry interested in a joint research project to contact Dr. D.B. Smith, Chief, Branch of Geochemistry, MS 973, Box 25046, USGS, Denver, CO 80225, TEL: (303) 236-1800.

R.W. Leinz
D.B. Hoover
USGS, MS 973, Box 25046
Federal Center
Denver, CO 80225

PRESS RELEASES

Alaska Opens Lands to Minerals

Alaska Governor Walter J. Hickel announced at the recent annual convention of the Alaska Miners Association that the State Department of Natural Resources will soon open more than 550,000 acres of Alaska State lands to mineral entry.

These lands have been closed to mineral entry (claim staking) by administrative orders during the past 18 years.

Governor Hickel's announcement came as a pleasant surprise to the mining industry. Steve Borell, Executive Director of the Alaska Miners Association said, "We knew that a review was in process but we did not realize the magnitude of the project." Borell continued, "This is precisely the kind of message that we want to send to the international minerals industry. For too long Alaska has been seen as an unfriendly place to do business and that has changed."

This action by the Hickel Administration is part of an ongoing effort by Alaska to encourage mineral development. During the previous session of the Alaska Legislature, a bill was passed that limits the amount of land that can be administratively closed to mineral entry to not more than 640 contiguous acres.

Once the mineral openings announced by Governor Hickel and the remaining state land selections are processed, the amount of state-owned land open to mining will total more than 96 million acres — nearly as much as the entire State of California. Additionally, the 12 Alaska Regional Native Corporations own more than 44 million acres of land, and they are actively seeking mineral development with major mining companies.

Borell also noted, "We are seeing a real shift in public opinion regarding mining. Most Alaskans, along with the majority of legislators, now realize that mining is the sleeping giant of the Alaskan economy and they are doing all they can to wake him up!"

For more information contact:
The Alaska Miners Association
203-601 West Northern Lights Blvd.
Anchorage, AK 99603

CT&E's Mobile, Alabama test facility registered

Dr. Michael A. Hildon, President, Commercial Testing & Engineering Co. (CT&E) announces the registration of CT&E's Mobile, Alabama facility to ISO 9002. This facility inspects, samples, and tests coal, coke from coal, and other materials, including iron ore, limestone, and petroleum coke. CT&E has plans to register over 20 of its facilities to ISO 9002 by the end of 1995.

Technical Notes

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The GMO pilot project 1992

Unlike the random sample distribution plans used for the geochemical maps just described, the GMO Pilot Project is based on a "meridian corridor" approach to "low density" geochemical mapping. A "meridian corridor" GMO is analogous to a soil map of a mineral prospect based on samples collected at regular intervals along lines located a fixed distance apart. Initially, the GMO is envisaged as "one degree" meridian corridor map as shown on Figure 2. This plan would include: 1) a province-wide corridor spacing interval of 1 degree of longitude (approximately 50 km); 2) sampling lines (corridors) 10 km wide; and 3) sample points 10 km apart along each of the corridors. This paper is concerned with an experimental corridor extending along the 80W meridian from Lake Erie to James Bay (Fig. 2).

The meridian corridor approach was planned for the GMO largely because it: 1) includes fewer sample points compared with a map based on random sampling at an average sample density of 1/500 km^2; 2) provides geochemical traverse patterns suitable for matching directly with landscape corridor data; and 3) simplifies the logistics of sample collection on an Ontario-wide scale.

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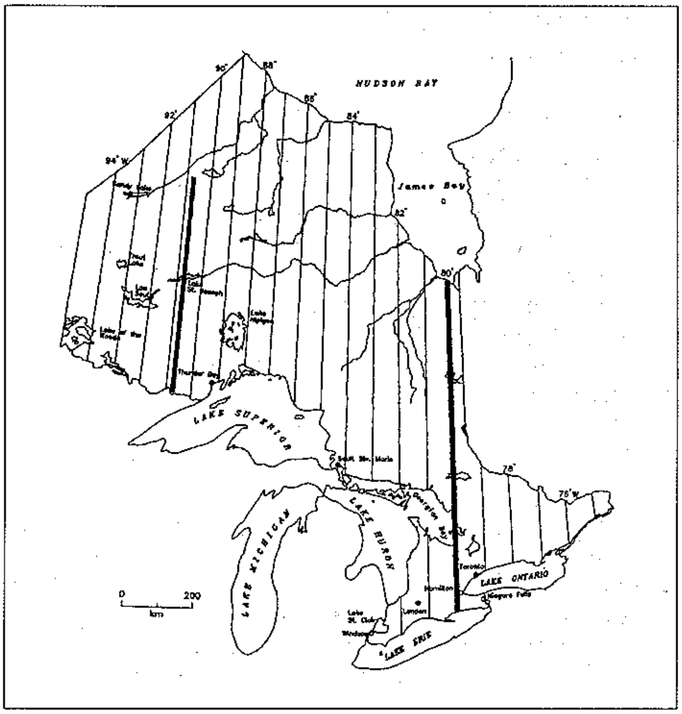

Figure 2. Map of Ontario showing: 1) the two meridian corridors sampled so far (thick lines); 2) the location of meridians which would be included in a hypothetical geochemical map of Ontario (thin lines). Note: this paper describes only the 80th meridian corridor sampled in 1992.

Technical Notes

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The 80W meridian corridor experiment

In June and July 1992, geochemical samples were collected from 94 adjacent 10 km x 10 km sampling cells positioned along the 80W meridian between Lake Erie and James Bay. The 80W meridian was chosen for the experiment because it: 1) traverses Ontario landscapes with maximum diversity with respect to: a) soil and vegetation cover; b) Quaternary cover; and c) bedrock. Another advantage is that, in general, the bedrock strikes at a relatively high angle to the 80W meridian trace. This should facilitate the detection of province-wide geochemical patterns of the type indicated in Figure 1.

Methods

In June and July 1992, samples of water, stream sediment and soil were collected from 22, 10 x 10 km cells located along the 80W meridian across the St. Lawrence Lowlands of Southern Ontario. Between sampling cells number 22 and 23 there is a major physiographic, bedrock geological and geochemical media change. The geochemical sample media change is from stream waters, stream sediments and "B" horizon soils in the south to lake waters and lake sediments to the north. In Northern Ontario, water samples together with pre- and post-*Ambrosia*[1] lake sediment core samples were collected from an additional 72 cells. In each cell, the sample point location plan was as follows. One geochemical sampling point was located at random in each 5 km x 5 km quarter-cell. Waters, soils, stream sediments and post-*Ambrosia* lake sediment samples were prepared and then composited (5 g from each pulp, 50 ml waters from each quarter-cell) prior to chemical analysis; resulting in one data point representing the entire 10 x 10 km cell. Pre-*Ambrosia* lake sediment data from each cell (up to four data points) were averaged to represent the entire 10 x 10 km area.

This paper is concerned with geochemical data obtained from stream and lake sediments and soil, "B" horizon samples only. The 10 x 10 km sample cell stream-sediment, soil "B" horizon and lake-sediment samples were analyzed for 41 elements. These included: 1) Major Elements - Al, Ca, Fe, K, Mg, Mn, Na, P, Ti; 2) Minor Elements - Ba, Br, Co, Cr, Cu, Ga, La, Nb, Ni, Pb, Rb, Sc, Sr, Th, U, V, Y, Zn; and 3) Trace elements -Ag, As, Au, Be, Cd, Ce, Cs, Hf, Li, Lu, Mo, Sb, Ta and W, and loss on ignition (LOI). Twelve of these data sets are discussed in this paper. Levels of Ca, Mg, P, Ni, Y, Be and Pb were determined in 0.2 g portions of sample digested in a multi-acid mix (HNO_3-HCl-HF-$HClO_4$), taken to dryness and the residue dissolved in HCl-HNO_3 prior to dilution to 10 ml with water and analysis by ICP-OES. Gold and As in the samples was determined by neutron activation. Data for Pb, Ni, Y, and P are considered "partial" extractions when determined by this method. Satisfactory quality control (i.e. precision and accuracy) results were obtained from replicated analyses of standard samples sequenced in the batches of unknowns samples.

Preliminary visual interpretation of the meridian corridor data sets was undertaken using "Quicklook Diagrams" (explained later). Prior to further processing, an ANOVA analysis (Marsal, 1987) was completed on the pre-*Ambrosia* data to determine if the "between" 10x10 km cell variance was greater than the "within" cell variance for all elements. The results of this analysis showed that the F-ratio ranged from a low of approximately 1.5 for Pb to approximately 11.1 for Be. This indicates that the variations along the meridian were more significant than the "within" cell variations.

More detailed examination of the data was completed using "Clarke Meridian Diagrams" which illustrate the geochemical patterns for each element in the 4 different sample media. This was followed by statistical analysis, with particular attention being paid to interelement and element/LOI relationships.

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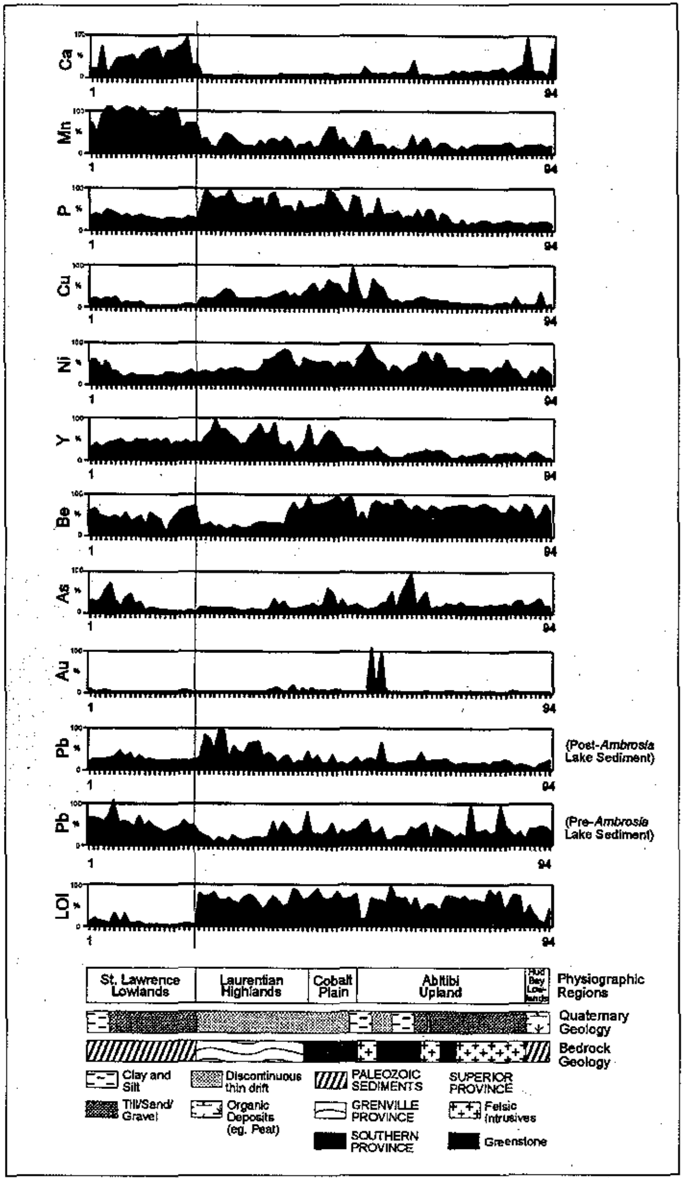

*Figure 3. An 80th meridian Quicklook diagram including sawtooth plots for nine elements (and LOI) in pre-*Ambrosia* lake sediment. Sawtooths for lead in both the pre- and post-*Ambrosia* lake sediment are included to illustrate a control and an anthropogenic geochemical pattern.*

---

[1] The *Ambrosia* pollen horizon is a convenient time-stratigraphic marker for 100 to 150 years ago in lake sediment cores collected from the Canadian Shield. This polen marker was found by palynologists to be generally between 14 and 19 cm below the top of cores taken from mid-basin lakes. During sampling, the 0-10 cm section is referred to as the "post-*Ambrosia*" sample and the portion below 20 cm as the "pre-*Ambrosia*" sample.

Technical Notes

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Figure 3 is an example of a Quicklook Diagram. The X-axis of the diagram has 94 tic marks, one for each 10 x 10 km cell sampled between Lake Erie and James Bay. At the bottom of the diagram bars denote meridian landscape information including: 1) physiographic regions; 2) Quaternary cover types; and 3) bedrock geology units. Above the bars are a series of "sawtooth" patterns produced by plotting 10 x 10 km cell geochemical data sets expressed as percentages of the highest ppm value. Figure 3 includes diagrams for: a) three major elements (Ca, Mn and P); b) three minor elements (Cu, Ni and Y); c) three trace elements (Be, As and Au); and for Pb in both pre- and post-*Ambrosia* lake-sediment and e) LOI.

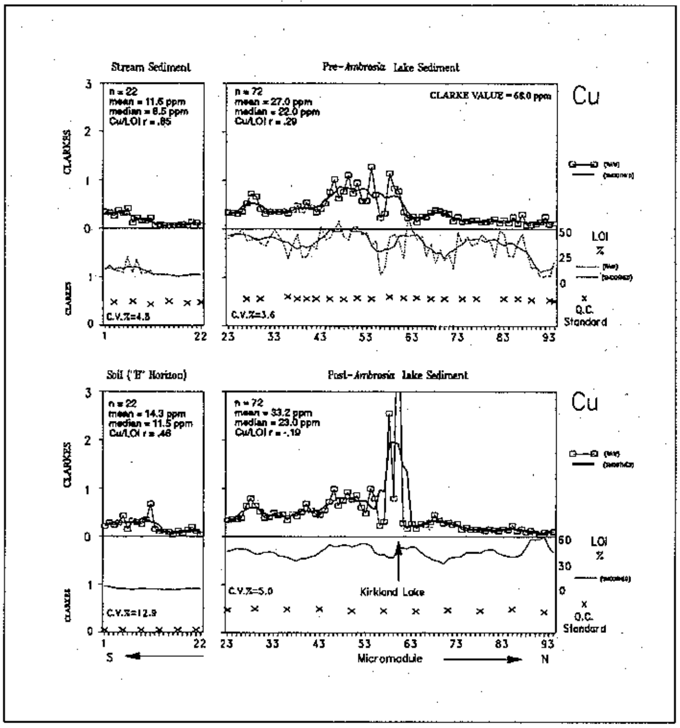

Figure 4. Clarke meridian diagram for Cu along the 80th meridian. The diagram includes four panels, one for each of the four sample media in which Cu was determined in the 80th meridian project.

Figure 4 is a Clarke Meridian Diagram showing chemical and geochemical relationships using Clarke units (Fortescue, 1985). Experience has shown that the inspection of these graph patterns (shown in greater detail in Fig. 5), provide information on geochemical data patterns in addition to that obtained from statistical analysis.

Results

It is evident from Figure 3 that limits of physiographic regions are closely associated with major changes in bedrock type. For example, Palaeozoic sediments underlie both the St Lawrence, and Hudson Bay, lowland regions. Landscapes in the Abitibi upland region are more complicated with variable overburden cover and Precambrian bedrock lithologies within the same physiographic region. The geochemical patterns for some elements indicate that regional landscape variations are accompanied by local "landscape geochemical noise". This is derived from landscape variations too small for inclusion in the meridian corridor data bars.

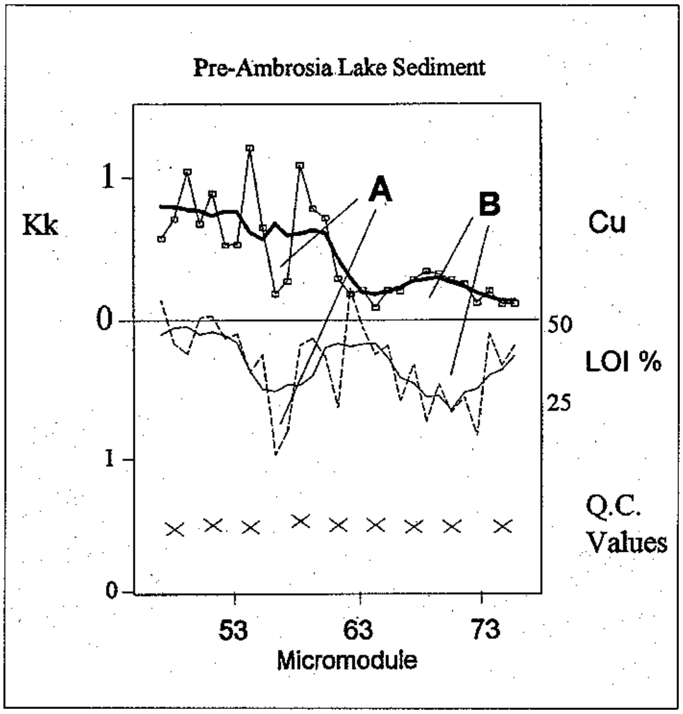

Figure 5. Detail of portion of Figure 4 showing variable LOI/ element relationships for Cu along meridian.

In Figure 3 the feature common to all the element sawtooth patterns is the important geochemical sample media change between sample cells 22 and 23 discussed previously. The details of this pattern change vary from element to element. For example, the Ca pattern has an abrupt change and no change is visible for Ni. In general, many of the patterns on the diagrams (e.g Cu, Y, Be, As etc.) resemble patterns on the Chinese conceptual model (Fig. 1).

Several Ontario-wide geochemical patterns are evident in Figure 3. The Mn and Ni patterns are typical for a major and a minor element which exhibit significant local landscape noise with isolated geochemical anomalies. The patterns for Ca and P in lake sediments both include significant Ontario-

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wide geochemical gradients (Fig. 3). The Ca gradient may reflect increasing calcium carbonate in the overburden as the Hudson Bay Lowlands are approached. The phosphorus (P) gradient pattern in the pre-*Ambrosia* data set (shown here) and in the post-*Ambrosia* data (not shown) requires further investigation.

The geochemical province patterns for Cu, Y and post-*Ambrosia* Pb most clearly resemble those on the conceptual model shown in Figure 1. The Cu data display (Fig. 5) includes: a) "geochemical background" (cells 12 to 22 and 63 to 94); b) a large "geochemical province" (cells 23 to 60); c) "regional geochemical provinces" (cells 1 to 10, 27 to 31 and 45 to 60); and a "geochemical anomaly" (cell 54). These patterns can be seen in more detail in Figure 4. Geologically, Cu patterns are associated with: (1) in southern Ontario a change in Palaeozoic rock type from sandstone to limestone; (2) an area of meso-Proterozoic mafic rocks in the central gneiss belt underlying the Laurentian Highlands just north of Parry Sound (cells 27 - 31); (3) Southern Province meta-sediments extending north from Lake Temagami (cell 45) north to Kirkland Lake (cell 60); and (4) an area of complex Archean geology overlain by clay, thick tills and organic terrain (cells 61 to 94).

The low Y signature from cells 61 to 94 is coincident with the geochemical background pattern of Cu. Higher Y from cells 23 to 60 is associated with Proterozoic rocks of the Grenville and Southern Provinces.

It has been known for some time (Dillon and Evans, 1982) that Pb has accumulated in post-*Ambrosia* lake sediment compared with pre-*Ambrosia* sediment sampled from the same core. In this study the pre-*Ambrosia* Pb data shows relatively low Pb in lake sediments north of cell 23. This is in sharp contrast to the post-*Ambrosia* data which has a strong negative Pb gradient from cell 23 northwards for a distance of 200km. This pattern is attributed to atmospheric fallout of particulate lead generated in Southern Ontario and elsewhere.

Trace element patterns for Be, As, and Au are also included in Figure 3. The Be pattern includes a rare "low" geochemical province pattern between cells 23 and 45 associated with Proterozoic rocks of the Grenville province. The As pattern is of interest because it has relatively high values in stream sediments in Southern Ontario (west of Hamilton) as well as in lake-sediments in northern Ontario. Although most of the Au values were below detection, it is interesting that a geochemical anomaly was found in the older (pre-*Ambrosia*) sediment at Kirkland Lake (cell 60).

In general, the sawtooth patterns on Figure 3 show a relationship between meridian corridor geochemical data patterns and the conceptual model (Fig. 1). It is concluded that, on an element to element basis, preliminary interpretation of meridian geochemical data patterns will focus attention on areas of geochemical interest along meridians. These patterns may then be examined in more detail visually, as shown in Figure 4 and with statistical procedures. In some cases, follow-up work would involve regional geochemical mapping of areas within and around the meridian corridor.

In addition to Quicklook diagrams, a series of 41 Meridian Clarke Diagrams were prepared from the 80W meridian data. Clarke units (Kk) are used throughout to plot quality control (QC) and 80W meridian geochemical data. Figure 4 is the Meridian Clarke Diagram for Cu (Clarke K = 68 ppm). The Figure includes: 1) detailed (10 x 10 km cell) data patterns and a five point moving average for Cu in each of four sample media collected along the 80W meridian corridor; 2) data for sample LOI accompanied by a 5 point moving average plot for the represented sample type (raw date is included for the stream sediment and pre-*Ambrosia* lake sediment graphs); 3) Cu mean, median and Cu/LOI correlation coefficient for each sample type; and 4) a plot (using crosses) for element values obtained from replicate analyses of a standard sample. The crosses denote where the standard replicates were located in each batch of analyses. The percent coefficient of variation for these replicates is also listed on Figure 4.

It was concluded from Figure 4 that: 1) the QC performance for Cu determinations is satisfactory (both graphically and numerically); 2) Cu levels in all four sample media are almost always less than 1 Clarke along the entire 80W meridian; 3) Cu is consistently higher in lake sediments compared with stream sediments (or soils); 4) the Cu/LOI relationship is not consistent along the length of the meridian traverse.

Figure 5 is an enlargement of a portion of Figure 4 which explains point 4) (above) in greater detail. The point "A" in Figure 5 shows where both Cu and LOI are relatively low compared with values obtained from adjacent samples. Further north, at "B", the opposite is true and LOI values decrease as Cu values increase; however, despite such local features the overall correlation coefficient (r) between Cu and LOI in pre-*Ambrosia* lake sediment is +0.29.

A distinct advantage of meridian corridor geochemical mapping is that spatial relationships of this kind are easily displayed. For this reason, the interpretation of patterns in element data sets should always include a combination of both spatial and statistical analysis.

Summary

In areas of Ontario with complex landscapes, we consider that geochemical sampling along meridian corridors superior to random sampling. In particular, meridian sampling

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facilitates the systematic separation of geochemical noise (i.e related to local landscape variations, sample matrix variability, drift in analytical precision) from province-wide geochemical signals of interest. If the corridor GMO approach were to be adopted, we consider that a map based on 21 meridian corridors (each 10 km wide) spaced one degree (circa. 50 km) apart would be adequate especially if each corridor is uniformly and systematically sampled as described above. In this way some 10% of the Province would be covered by corridors with an average corridor sample density of 1/25 km^2 and an average 10 x 10 km cell sample density of 1/100 km^2 (based on four sample composites). For maximum effectiveness, a corridor-based GMO should be linked to a flexible regional geochemical mapping program as mentioned above.

Previous experience in regional geochemical mapping in Southern Ontario (based on stream sediments); and in Northern Ontario (based on lake sediments and waters) has demonstrated that these media may describe geochemical patterns of the type required for the GMO (Fortescue, 1992). Experience obtained from the 80th meridian experiment demonstrates that geochemical patterns associated with geology and landscape conditions can be resolved. In addition the 80th meridian experience suggests that much of the noise in the lake sediment data is attributable to variations in the mineral/organic ratio within samples. This can be minimised by ensuring, at sampling and/or during data reduction) that LOI values fall in the range of 20% to 50%. In addition, the problem of discerning between noise related to LOI variability and true geochemical signatures requires that the data always be examined spatially, in conjunction with statistical analysis.

In 1992, a crew of two samplers collected all 94 corridor geochemical samples. This experience indicated that: (1) in Southern Ontario a "truck based" stream sediment sampling rate of 20 meridian km/day could be maintained; and (2) in Northern Ontario a "helicopter based" lake sediment sampling rate of 60 km per day could be maintained.

Conclusions

The following general conclusions were drawn regarding experience with the GMO Pilot Project to date:

1) It is logistically feasible to produce a GMO based on meridian corridors.
2) A meridian corridor based GMO would have certain advantages over a similar map based on "low density" random sampling of the entire province. For example, meridian corridor geochemical sampling based on 10 x 10 km cells with an average density of 1/100 km^2 provides continuous geochemical maps which can be directly interpreted spatially in relation to physiographic, geological, and geochemical model sections (see Fig. 1).
3) The effectiveness of a meridian based GMO would be greatly enhanced if it is supported by a limited use of regional geochemical mapping in areas of maximum interest.

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Acknowledgement

The writers are most grateful for a constructive review of the manuscript by an anonymous reviewer. The chemical data used in this paper was obtained from Bondar-Clegg Ltd. under contract to the Ontario Geological Survey. This paper is published by permission of the Director of the Ontario Geological Survey. Views expressed here are those of the writers and do not necessarily reflect policy of the Ontario Geological Survey. The GMO Pilot Project is part of the five year Canada-Ontario 1991 Northern Ontario Development Agreement (NODA).

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The Use of Silica Sand Cleaners in Pulverizing Mills to Reduce Cross Contamination

Samples submitted to a commercial laboratory can range from crustal abundances to high concentrations measured as percentages. In many cases batches of samples are submitted without separating highly mineralized samples from the remainder of the samples and sometimes even the geologist cannot recognize metal-rich samples in the field. The principal concern in treating such diverse samples is the possibility of cross-contamination during preparation for geochemical analysis. To reduce the risk of cross-contamination, particularly during pulverization of rock samples, the standard pulverizing procedure recommended is:

(a) pulverize a 150 g sample,
(b) transfer the pulverized material to a vial,
(c) use compressed air to blow off any remaining dust in mill, and
(d) pulverize approximately 75 g of silica sand and empty the mill.

This silica sand wash procedure (step d) is used to thoroughly clean the mill after every sample.

To test the efficiency of the cleaning, flakes of gold weighing: 1) 0.0034 and 2) 0.0069 g were pulverized with 100 or 200 g of silica sand to simulate grades of 17, 34 and 69 ppm (0.5, 1.0 and 2.0 ounces per ton). After pulverizing each gold-bearing sample, two 75 g aliquots of sand were pulverized in the same mill, and subsequently assayed.

The entire sand cleaner sample was analyzed by a fire-assay method with instrumental finish, utilizing 30 g subsamples. The results are shown in Table 1 and displayed graphically for the 34 ppm (1 opt) sample in Figure 1.

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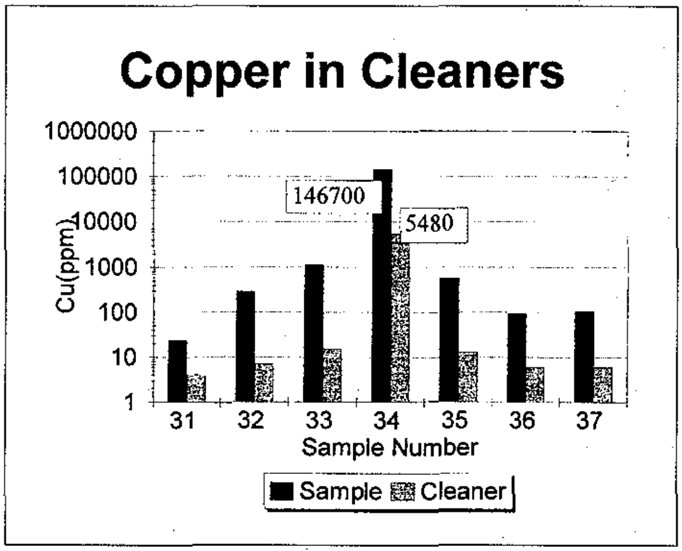

Figure 1. Analytical results of "salted" 34 ppm gold sample and subsequent silica sand cleaner material.

Table 1. Determination of gold in silica sand cleaners

Wt. of Gold(g)/ Wt. of Sand(g)	Sample Weight (g)	Gold Assays (ppm)	Weighted Average (ppm)	% Carry -over
0.0034/200	166.06	20.5, 13.4, 16.6, 18.5, 17.2, 16.9	17.2	1
Cleaner 1	134.42	0.18, 0.19, 0.43, 0.11, 0.10	0.21	
Cleaner 2	68.70	Tr, Nil, Nil	Nil	
0.0034/100	99.16	37.7, 33.2, 27.9, 28.4	32.5	1
Cleaner 1	69.46	0.44, 0.32, 1.02	0.47	
Cleaner 2	69.60	0.06, 0.05, 0.06	0.06	
0.0069/100	98.93	72.7, 51.7, 78.0, 56.7	66.5	0.3
Cleaner 1	69.05	0.33, 0.19, 0.18	0.25	
Cleaner 2	68.90	0.04, 0.04, 0.06	0.04	

The variation of the gold assays for gold-bearing samples is related to the inhomogeneity of the material, commonly referred to as the "nugget effect". The experimental design represents the "worst case scenario" as the gold was introduced as one or two grains.

The weighted average of the gold results indicates that almost 100% of the gold was recovered by the fire assay procedure when the entire sample is analyzed. There were losses attributable to the fire assay procedure but approximately 1% of the gold remained in the pulverizing equipment and was transferred to the subsequent silica sand cleaners. The transfer of gold metal to subsequent samples was anticipated due to the malleable nature of the metal and the probability of smearing on the pulverizing equipment.

Silica sand cleaners were also analyzed to test the degree of base metal contamination. A suite of drill core samples from a base metal prospect were submitted for 31 element ICP determination. The silica sand cleaners used to clean the pulverizer were analyzed by the same method. A massive sulphide mineralized zone was encountered in this drill hole and several samples returned high Cu, Zn, As and Sb values (Table 2 and Figure 2).

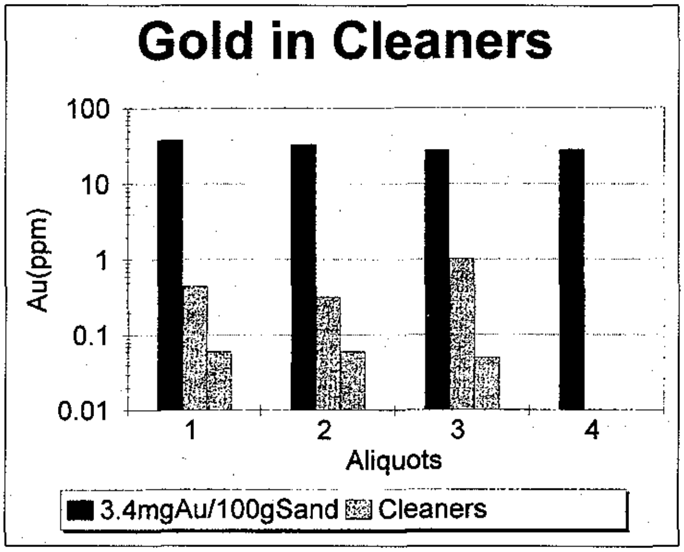

Figure 2. Analytical results of routine drill samples and subsequent silica sand cleaner material.

Table 2. Determination of base metals in routine samples and subsequent silica sand cleaners

Sample No	Cu(ppm)	Zn(ppm)	As(ppm)	Sb(ppm)	Fe(%)
31	24	57	1990	11	3.37
Cleaner	4	2	11	2	0.43
32	289	187	55	70	7.30
Cleaner	7	4	2	6	0.49
33	1130	383	464	185	4.21
Cleaner	15	5	4	10	0.44
34	146700	28600	7190	64300	18.3
Cleaner	5480	998	235	2380	1.2
35	568	120	3910	210	9.36
Cleaner	13	3	19	9	0.50
36	93	97	10000	43	16.00
Cleaner	6	3	80	6	0.60
37	105	66	159	30	4.56
Cleaner	6	3	4	2	0.47

The results for the silica sand cleaners demonstrates that the values are generally low and represent 1 to 6% of the value reported for the preceding sample. In most cases, the silica sand cleaner contains less than 10 ppm of most metals and would not generally be considered significant; however,

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the highly mineralized samples create a potential problem, as a significant amount of metal apparently remains in the pulverizing equipment. If low-grade sample 35 were pulverized immediately after base-metal-rich sample 34 and a silica sand cleaner had not been used, Cu values would have been approximately 500% higher than the actual metal concentrations. Antimony values would have been similarly affected.

It can be argued that this type of contamination would be easily recognized, but in a commercial laboratory the next sample pulverized in the mill is not necessarily the subsequent sample down the hole or along a sample line. Frequently several mills are used concurrently when preparing a customer's sample. Erroneous values in the order of 2,000 ppm Cu, 500 ppm Zn or 1,000 ppm Sb, could be very misleading if they were reported in samples scattered throughout the sample batch.

The potential for cross-contamination from other samples is dependent on:

- relative metal concentrations
- samples with high sulphide or clay mineral content that are likely to adhere to the pulverizing equipment.

In summary cross-contamination can be controlled by using a silica sand cleaning procedure in grinding and by submitting highly mineralized samples separately or distinguished from other samples so that the laboratory can treat them accordingly.

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ANALYST'S COUCH

Labs take note — clean-up procedure for litharge used in fire assay

Those attending the analytical workshop at the 16th IGES held recently in Beijing were particularly interested to learn of a clean-up procedure for the flux used in the classical Pb fire assay preparation for precious metal determination. Lin Yunan of the Ministry of Geology and Mineral Resources in Zheng Zhou, China, described his method to determine Au, Pt and Pd in geochemical materials by emission spectrometry following separation and preconcentration of the analytes by the usual Pb fire assay technique. Key to attaining the impressive detection limits of 0.1 ppb for Au and Pd and 0.2 ppb for Pt in a 10g sample was the use of litharge (PbO) which had been converted to the subcarbonate in a purification step. This clean-up procedure resulted in contents of Au, Pt, and Pd below 0.05 ppb in the carbonate itself ($PbCo_3 2Pb(OH)_2$). In trying to improve detection capability for precious metals, employing such sensitive techniques as ICP-MS, it has been my experience that contamination through the fire assay procedure, mainly from the contribution to blank levels from the flux, has been the limiting factor. For example, a combination of ICP-MS analysis and Pb fire assay preparation, using both optimum experimental conditions for maximum sensitivity and dedicated equipment (e.g., furnace, crucibles) for processing low-level samples, can achieve detection limits of 1 ppb for Au, 0.3-0.4 ppb for Pd and 0.1 ppb for Pt on a 10g sample. Only for Pt is the sensitivity of ICP-MS being used to the full, the limiting factor for Au (especially) and Pd being the magnitude and variability of the blank introduced during fire assay (Hall, 1992, J. Geochem. Explor., 44:201-249). I am anxious to determine detection limits after incorporating this purification step.

Here is Lin Yunan's procedure:

Treat 1.2 kg of litharge (PbO) in a 5000 ml beaker with 630 ml of 99% acetic acid and 3500 ml of water. Stir the contents for 25 min. Add a solution prepared by dissolving 1 g of diphenylthiourea in 15 ml of hot acetic acid (99%) and stir the contents for 2 h to precipitate the noble metals. Add 1g of activated charcoal and stir for 1 h. Filter off the residue. Add a hot saturated solution of sodium carbonate to the filtrate until the pH reaches 8. Filter off the product, wash with water and dry at 150°C. The resulting carbonate should weigh about 1.33 kg.

G.E.M. Hall
Geological Survey of Canada

INTERNATIONAL GEOCHEMICAL MAPPING

IGCP 360 - Global Geochemical Baselines

For whatever purpose geochemistry is used, there is an underlying need to know the background values of the elements of interest. Some countries have recognized this need and have produced REGIONAL geochemical maps and atlases. In other countries, there is a wealth of geochemical data requiring collation and synthesis.

The IGCP Scientific Committee has endorsed a new project - Global Geochemical Baselines which has the support of several scientific and professional bodies. The AEG Council, recognizing the relevance of the objectives, has unanimously agreed to give it official AEG support.

Many of our members are already contributing to this project and to government-sponsored production of

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geochemical maps. Such data are invaluable in mineral exploration, environmental monitoring, agriculture, forestry and human health, and it is the geochemist who can best provide this data. If you want more information, or even better, wish to contribute to IGCP 360, please contact Arthur Darnley at the address shown at the end of the accompanying article.

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International Geochemical Mapping and Global Geochemical Baselines

A recent publication issued from Stockholm by the International Geosphere-Biosphere Program of the International Council of Scientific Unions stated: "Several surveys have revealed a dearth of global information for many attributes of the land surface. Such global sets as do exist are largely derived from the piecemeal collation of diverse data sets, which leads to major problems of spatial and categorical consistency." (Global Change Report No. 20). Earth Scientists are well aware that global science is data-limited, and this certainly applies in the field of geochemistry.

Efforts to remedy the situation referred to above began six years ago. News items concerning the International Geochemical Mapping project and the start of Phase 2, Global Geochemical Baselines, have been carried in a recent number of the JGE (vol. 48, pp. 97-104) and in **EXPLORE** (No. 81, October 1993). The final version of a report, "geochemical mapping" is now being edited for publication in 1994. The executive summary from this report will be included in a forthcoming number of **EXPLORE**. The report has been written with two audiences in mind, professional scientists concerned with the chemical composition of the earth's surface, and the institutions that fund the acquisition of such knowledge. The production of this report is an essential first step towards the collection of systematic baseline data.

How can the work proceed? It can not be undertaken as a marginal activity, a part-time hobby for a few dedicated enthusiasts! It has to be officially supported, or at least endorsed, at both a national and international level. In order to obtain a global geochemical database the following practical considerations need to be addressed:

- data acquisition will require a minimum of a decade, it could be much longer;
- the quality and consistency of data must be controlled throughout the acquisition period;
- standard reference materials must be provided and renewed as necessary;
- there should be a mechanism for assessing and introducing new techniques as they become available;

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- there should be a central record of work undertaken;

Further considerations include:

- global and regional data must be accessible to be useful;
- a single world geochemical data centre is required to facilitate links to other global-scale phenomena, geoscience, population, environmental and global change datasets.

In fact, the whole operation has to be managed as carefully as the acquisition of any other world data set; management continuity and assured funding are required. The activity requires coordination by a small technical secretariat, funded through one of the existing international organizations.

Unfortunately, as earth scientists are too well aware, surface data collection concerning the earth's composition has never attracted a high level of financial support. Contrast the attention given in recent years to astronomical observations. Two current news items emphasize this point; the Martian space probe (recently disappeared) and the Hubble telescope (under repair)! The cost of either of these missions would have paid for a very adequate global geochemical reconnaissance, and sufficient money would have been left over to donate a geochemical atlas to every university and high school in the world!

So, what can geochemists do to change public priorities? Several actions are needed. Geochemists must endeavour to become more influential by delivering information in terms the public can understand. Geochemists should emphasize the need to know the chemical composition of the environment in which we live. Professional geochemists can help themselves by making greater efforts to associate on a regional basis, to discuss ways of working in a more systematic fashion. Regional associations are needed which can meet with the principal scientific and financial institutions in each region.

Unless geochemists take some initiative at the local, grass-roots, level, the actions which can be taken by the project's steering committee, whereby the principal world scientific and financial organizations will receive copies of the report, will have little effect. Obviously, any call for new expenditures must be justified by strong evidence of practical benefits (for example, do the environmental guidelines established in your area take natural background variations into account??), otherwise the authorities will pay no attention.

Informal talks with UN and national technical assistance agencies during the past year have made it clear that in order for a new project to be considered for support it should be requested by a group of countries. It should relate to an infrastructure requirement which will produce demonstrable benefits, and it should be organized in such a way as to encourage regional cooperation.

As a first step to the establishment of global geochemical baselines, (and perhaps as a means of ensuring continuing and expanding employment for geochemists!), you are urged to communicate with your neighbors and assist in forming a regional group! If you need help in identifying who to talk to, fax or write the undersigned. The project now has contacts in 90 countries, so there are a lot of organizations and individuals out there who are interested!

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JOURNAL OF GEOCHEMICAL EXPLORATION

Two volumes of the JGE are due to be published early in 1994. Their contents are listed here for the interest of readers.

Volume 49 Nos 1,2 Special Issue

Geochemical Mapping

Edited by P.H. Davenport

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Environmental aspects of the regional geochemical survey in the southern part of East Germany
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Geochemical mapping employing active and overbank stream-sediment, lake sediment and lake water in two areas of Newfoundland
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Comparison of geochemical patterns obtained from stream sediment, stream organics and till in the Nordkalott project in Fennoscandia
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Geochemical mapping in Newfoundland and Labrador: its role in establishing geochemical baselines for the measurement of environmental change
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Fluid evolution and Au-Cu genesis along a shear zone: a regional fluid inclusion study of shear zone-hosted alteration and gold and copper mineralization in the Kautokeino greenstone belt, Finnmark, Norway
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Discrimination of topaz rhyolites by major element composition; a statistical routine for geochemical exploration
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International, National and Regional Meetings of Interest to Colleagues Working in Exploration and Other Areas of Applied Geochemistry.

■Jan. 17-19, '94 **Minerals** colloquium, Ottawa, Canada, by Geological Survey of Canada (Carol Blais, GSC, Room 686, 601 Booth St., Ottawa K1A OE8; TEL: (613)996-1600; FAX: (613)996-9820)

Feb. 14 '94 **Association of Exploration Geochemists - ANNUAL GENERAL MEETING,** in conjunction with the SME Convention, 1:00 - 2:00 pm, Doña Ana Room, Albuquerque, NM (B. Arseneault, Business Mgr. AEG, PO BOX 26099, 72 Robertson Road, Nepean, Ontario K2H 9R0 CANADA; TEL: (613)828-0199)

■Feb. 14-17, '94 **Integrating Mining and the Environment,** SME, Annual Meeting, Albuquerque, NM (Meetings Dept., SME, PO BOX 625002, Littleton CO 80162-5002 USA; TEL: (303)973-9550; FAX: (303)979-3461)

■Feb. 22-25, '94 McKelvey Forum on **mineral resources,** Tucson, Arizona (Warren C. Day, U.S. Geological Survey, MS905, Box 25046, Denver Federal Center, Denver, Colorado 80025; TEL: (303)236-5568; FAX: (303)236-5603)

■Mar. 5-9 '94 **Global exploration and development,** Int'l mtg., by Prospectors and Developers Assoc. of Canada, Annual mtg., Toronto (S. Lawton, PDAC, 1002-74 Victoria St., Toronto ON M5C 2A5 CANADA; TEL: (416)362-1969; FAX: (416)362-0101)

■Mar. 14-17, '94 Geology and **energy and mineral resources of Vietnam,** mtg., Hanoi, by Circum-Pacific Council for Energy and Mineral Resources, and Geological Survey of Vietnam (Mary Stewart, Suite 500, 5100 Westheimer, Houston, Texas 77056; TEL: (713)622-1130; FAX: (713)622-5360)

■Apr. 5-8, '94 **Minequest:** Pacific Northwest **metals and minerals** conference, Spokane, Washington (Andrew W. Berg, U.S. Bureau of Mines, E. 360 Third Ave., Spokane, Washington 99202; TEL: (509)353-2700)

■Apr. 17-20, '94 Extractive-industry geology, mtg., Sheffield, England (Institution of Mining and Metallurgy, 44 Portland Place, London W1N 4BR, United Kingdom; TEL: +44 71 580 3802; FAX: +44 71 436 5388)

■May 1-4 '94 **CIM Toronto '94** CIM Annual mtg., Toronto (D. Harquail, General Chairman, Toronto '94, 2000-20 Eglinton Ave. W., Toronto ON M4R 1K8 CANADA; TEL: (416)480-6497; FAX: (416)488-6598)

■May 10-14, '94 **Mining Latin America,** mtg., Santiago, Chile, coincident with **EXPOMIN 94** (IMM, 44 Portland Place, London W1N 4BR UK; TEL: 44 71 580 3802; FAX: 44 71 436 5388)

■May 13-18 '94 **GAC-MAC** Annual mtg., and **MDD-GAC** short course on **alteration processes,** Waterloo (G. Roberts, Waterloo'94, Dept of Earth Sci., Univ of Waterloo, Waterloo ON N2L 3G1 CANADA; TEL: (519)885-1211; FAX: (519)746-7484; Shortcourse info see ad on Page 15 of this issue or contact D.R. Lentz, GSC, PO BOX 50, Bathurst NB E2A 3Z1 CANADA; TEL: (506)546-2070; FAX: (506)546-3994)

■May 17-19, '94 **GAC-MAC,** Annual mtg., Edmonton (J.W. Kramers, Alberta Geological Survey, Box 8330, Station F, Edmonton AB T6H 5X2 CANADA; TEL: (403)438-7644; FAX: (403)438-3364)

■Aug. 28-Sept. 3, '94 European Association of Geochemistry Meeting and **4th Goldschmidt** Conference, Edinburgh (Dr. B. Harte, Department of Geology and Geophysics, Grant Institute, University of Edinburgh, West Mains Road, Edinburgh EH9 3JW UK)

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Calendar of Events

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Sept. 8-12, '94 Joint International Symposium on **Exploration Geochemistry**, Irkutsk: a tribute to Academician L.V. Tauson (Pavel Koval, Institute of Geochemistry, PO BOX 4019, 664033 Irkutsk-33 RUSSIA; TELEX: 133 163 Taiga SU; TEL: 395(2)46-59-78)

▪Sept. 12-15, '94 3rd International Symposium on **Environmental Geochemistry**, Krakow, Poland (Dr. E. Helios Rybicka, Faculty of Geology, University of Mining and Metallurgy, Al Mickiewicza 30, 30-059 Krakow, Poland; FAX: 48-12-32936)

▪Sept. 18-22 '94, **Geoanalysis '94**, International symposium on analysis of geological and environmental materials, UK (D.L. Miles, British Geological Survey, Keyworth, Nottingham NG 12 5GG UK; TEL: 44 602 363100; FAX: 44 602 363200)

▪Sept. 26-28, '94 **Mineral Exploration** '94 (including a 1-day symposium on **Latin American mineral deposits**), Lake Tahoe, Nevada, U.S.A. (Dr. Phil Newall & Dr. Alan Butcher, CSM Associates Ltd., Pool, Redruth, Cornwall TR15 3SE, United Kingdom; TEL: +44 (0)209 717724; FAX: +44 (0)209 716977)

▪Oct. 25-27, '94 Geological Society of America, Annual mtg., Seattle, WA (V. George, GSA, Box 9140, Boulder CO 80301 USA; TEL: (303)447-2020)

▪Mar. 6-9, '95 SME Annual Meeting and Exhibit, Denver, CO (Meetings Dept., SME Inc. PO BOX 625002, Littleton CO 80162-5002 USA; TEL: (303)973-9550; FAX: (303)979-3461)

▪Apr. 3-7 '95 **Centennial Geocongress 1995** Johannesburg, The Geological Society of South Africa (The Congress Secretariat, Centennial Geocongress, PO BOX 36815, Menlo Park 0102 SOUTH AFRICA; TEL/FAX: +27 12 47 3398)

▪Apr. 10-13, '95 Geology and **Ore Deposits of the American Cordillera**, Geological Society of Nevada Symposium III, Reno (B. Hatch, GSN, PO BOX 12021, Reno NV 89510 USA; TEL: (702)323-4569; FAX: (702)323-3599)

May 15-19, '95 17th International Geochemical Exploration Symposium, "**Exploring the Tropics**", Townsville (R. Myers, 17 IGES, National Key Centre in Economic Geology, James Cook University, Townsville QLD 4814 AUSTRALIA; TEL: 077 814486; FAX: 61 77-815522)

▪June 7-9 '95 **African Mining '95**, Windhoek, Namibia (IMM, 44 Portland Place, London W1N 4BR UK; TEL: +(071)580 3802; FAX: +(071) 436 5388)

▪Nov. 6-9, '95 Geological Society of America, Annual mtg., New Orleans, LA (V. George, 3300 Penrose Place, Boulder CO 80301 USA; TEL: (303)447-2020; FAX: (303)447-1133

Please check this calendar before scheduling a meeting to avoid overlap problems. Let this column know of your events.

Fred Siegel
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RECENT PAPERS

This list comprises titles that have appeared in major publications since the compilation in **EXPLORE** Number 81. Journals routinely covered and abbreviations used are as follows: Economic Geology (EG); Geochimica et Cosmochimica Acta (GCA); the USGS Circular (USGS Cir); and Open File Report (USGS OFR); Geological Survey of Canada Papers (GSC Paper) and Open File Report (GCS OFR); Bulletin of the Canadian Institute of Mining and Metallurgy (CIM Bull): Transactions of Institute of Mining and Metallurgy, Section B: Applied Earth Sciences (Trans IMM). Publications less frequently cited are identified in full. Compiled by **L. Graham Closs**, Department of Geology and Geological Engineering, Colorado School of Mines, Golden, CO 80401-1887, Chairman AEG Bibliography Committee. Please send new references to Dr. Closs, not to **EXPLORE**.

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ASSOCIATION OF EXPLORATION GEOCHEMISTS APPLICATION FOR ADMISSION

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Field of interest selection 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐
(Insert number in box)

1. Drainage (streams & lakes)
2. Soils
3. Lithogeochemistry
4. Biogeochemistry (geobotany)
5. Gas geochemistry
6. Heavy minerals
7. Statistical methods
8. Analytical instrumentation
9. Analytical procedures
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